Hydrostatic and Nonhydrostatic Nested Modeling of Straits in the Philippines Archipelago

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LONG-TERM GOALS

This study utilizes nested nonhydrostatic models embedded in hydrostatic models to simulate and predict the submesoscale dynamics of straits at high spatial and temporal resolutions. The goal of this work is to understand the submesoscale dynamics of straits and the impact of these dynamics on the throughflow in the straits. The Navy requires the ability to forecast features and circulations forced by these dynamics on scales that impact naval operations, kilometers to meters.

OBJECTIVES

The primary objective is to understand the submesoscale dynamics in straits using nested nonhydrostatic models embedded in hydrostatic models. Specifically we will work

- To understand the effects and interactions of the primary forcing components:
    - Tides, especially the spring-neap tidal cycle and remotely versus locally generated tides,
    - Large scale circulation, particularly the Pacific to Indian ocean throughflow and it's seasonal variability,
    - Winds, especially the Southeast Asian monsoon cycle,
- To establish the resolution (dx and dz) and the aspect ratio (dx/dz) required to accurately simulate submesoscale physics and structures,
- To determine the importance of accurate and detailed representation of topography and forcing, especially at open boundaries,
- To understand the impact of rotation on the flow in straits, this is particularly important to nonhydrostatic physics,
- To explore the impact of data assimilation in a nonhydrostatic model, especially for sparse and irregular data,
- To compare model and field observations both for planning and for assessment.

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APPROACH

We use a system of multiply nested nonhydrostatic model (NRL-MIT) domains which utilize hydrostatic models (NCOM and/or HYCOM) to provide open boundary conditions for the coarsest NRL-MIT domain. The NRL-MIT domains consist of the nonhydrostatic version of the MITgcm model wrapped in a suite of scripts that provide initial/restart fields, open boundary values and handle output in a series of segmented, parallel integrations that maximize cpu usage and the ratio of system to wall clock time. The forcing consists of surface fluxes from the NOGAPS and COAMPS operational nowcast/forecast systems and open boundary conditions from the NCOM and/or HYCOM nowcast/forecast systems. HYCOM forecasts with resolutions of up to 4 km may be available in the region in the next year or two (Harley Hurlburt, personal communication). The basic bathymetry will be the NRL DBDB2 (2 minute) bathymetry which we hope will be enhanced and improved with several additional bathymetry databases obtained during the DRI.

WORK COMPLETED

We have designed the NRL-MIT domain for the Surigao Strait (Figure 1) which will be our initial hindcast domain. Code has been added to the nonhydrostatic MITgcm model to allow the coordinate system of the model domain to be rotated relative to the earth-centered spherical polar latitude/longitude grid. The changes were tested successfully. The transports from the EAS16NFS have been collected for analysis (Figure 2). These were provided by Ms. Shelley Riedlinger.

RESULTS

Although the transport into the Surigao strait is highly variable, monthly and interannually, the mean is 1 to 2 Sv into the strait at the 100 m isobath where the NCOM transports were calculated. Also tidal flow measured in the Surigao strait during the exploratory cruise showed tidal speeds of up to 6 m/s through the Surigao strait into the Bohol Sea. Flow up a steep slope from deep water, such as up the slope immediately on the Pacific side of Surigao strait can generate NLIWs with large amplitudes. These are the waves we are studying in the Surigao strait.

IMPACT/APPLICATIONS

Tactical scale or submesoscale forecasting in domains of 100 to 200 km will require nonhydrostatic modeling systems with resolutions of 100s of meters or less to correctly predict the NLIWs, turbulent regions, fronts, boils and small scale eddies. This project studies the dynamics of NLIWs, their interactions and their impact on the tactical environment. This work furthers the basic understanding of NLIWs and lays the foundation for fututre nonhydrostatic forecast systems.

RELATED PROJECTS

This project is synergistic with the following projects:
NonLinear Internal Wave Initiative (NLIWI) ONR DRI,
Integrated Sub-Mesoscale/Acoustic Modeling, NRL 6.2 core
Effects of Non-Acoustic Noise on Multi-Sensor USW Networks, NRL 6.2 core
Horizontal Array-Gain Variability due to Transverse Shelf-break Dynamics, NRL 6.2 core

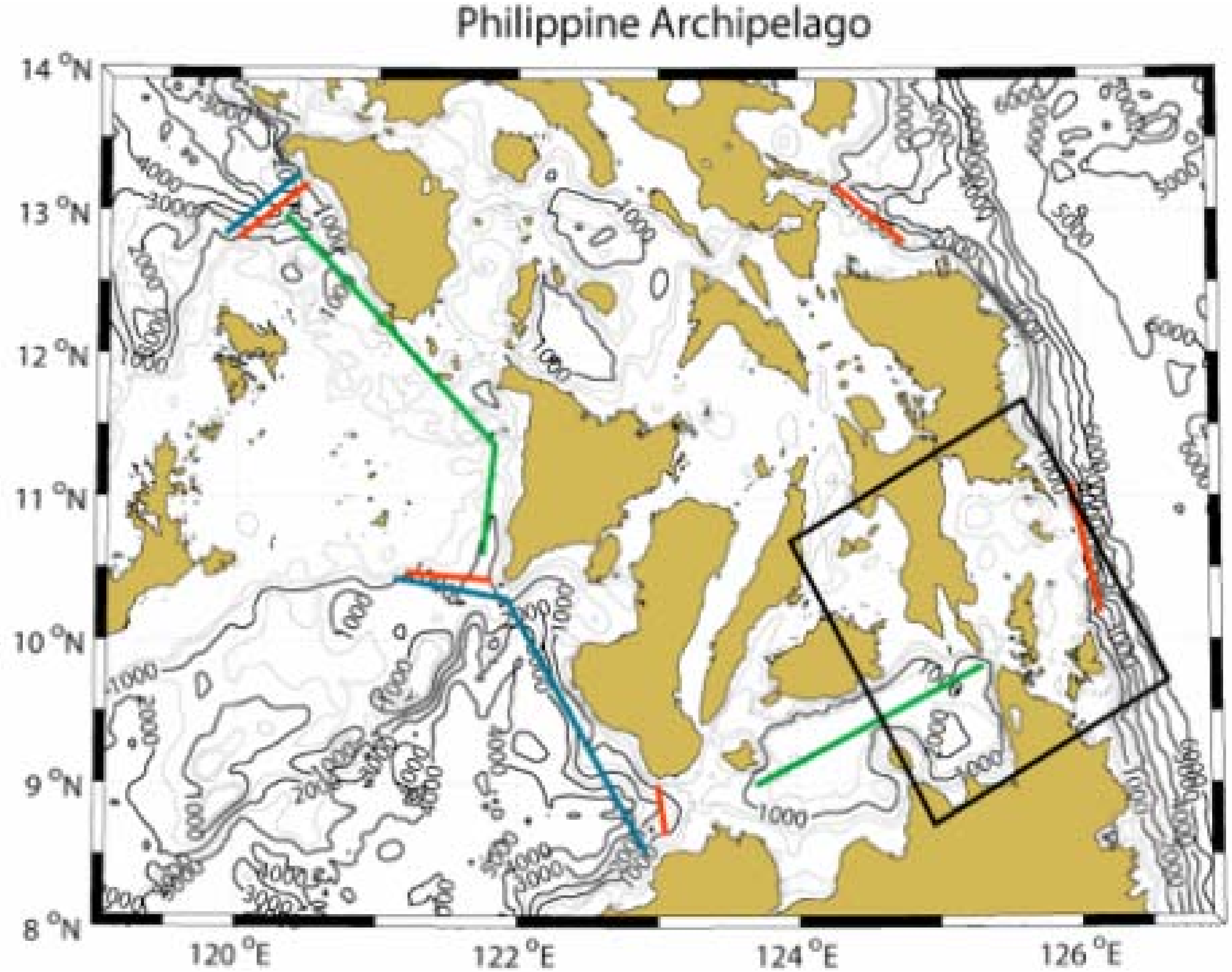

Figure 1. Philippines Archipelago showing the placement of the NRL-MIT Surigao Strait domain. The domain is rotated and sized to minimize extraneous land points and to place the northeast side nearly parallel to the steep slope of the Pacific basin.

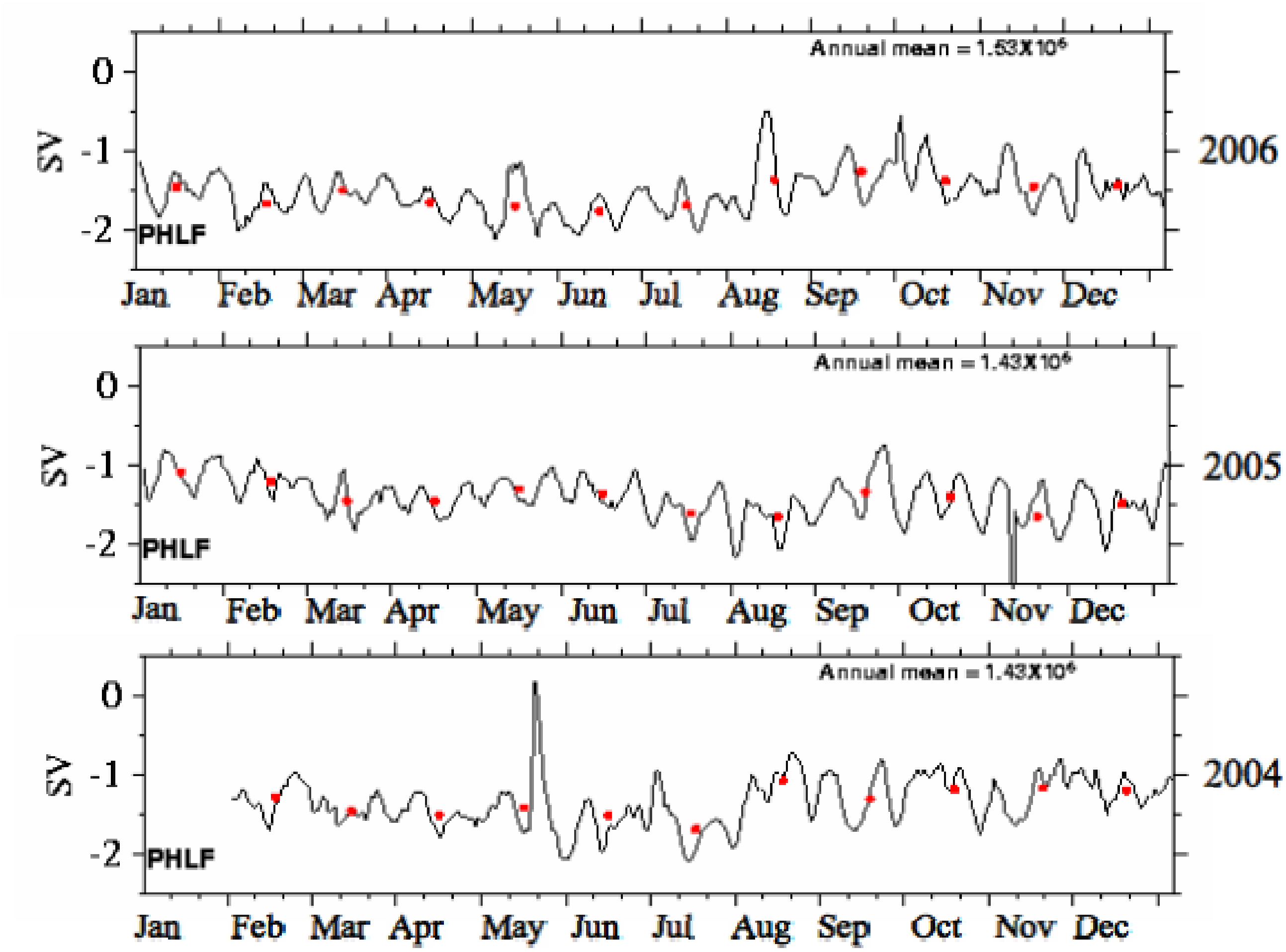

Figure 2. Daily transport through the eastern boundary of the Surigao Strait at the 100 m isobath. Red dots are the monthly average transport. Although there is significant monthly and interannual variation the average transport is into the strait at between 1-2 Sv. Data is from the EAS16NFS courtesy of Ms. Shelley Riedlinger.